

# NEW\_HYPERZ (v12.2)

## NEW\_HYPERZ : AN OVERVIEW

---

The New\_Hyperz code is an updated version of the public code « Hyperz » originally described in Paper I (Bolzonella, Miralles & Pello, 2000, [A&A 363, 476-492](#)), distributed at <http://webast.ast.obs-mip.fr/hyperz/>. The new version v12.2 presently under development is intended to improve several aspects of the algorithm as described below. The algorithm is written in fortran. In addition to the photometric-redshift code, the final package should include different libraries of templates (galaxies, stars and QSO), both synthetic and empirical, and a library of filter transmissions.

The New\_Hyperz algorithm is based on the SED fitting procedure using a standard  $\chi^2$  minimization procedure. The observed SED of a given galaxy is compared to a set of template spectra as follows :

$$\chi^2(z) = \sum_{i=1}^{N_{\text{filters}}} \left[ \frac{F_{\text{obs},i} - b \times F_{\text{temp},i}(z)}{\sigma_i} \right]^2,$$

where  $F(\text{obs})$ ,  $F(\text{temp})$  and  $\sigma$  are the observed and template fluxes and their uncertainty in filter  $i$ , respectively, and  $b$  is a normalization constant. Figure 1 below presents the flow chart of the algorithm. The basic User's Manual can be found at <http://webast.ast.obs-mip.fr/newhyperz/> in html version, and an updated version is given with the distribution (hyperz\_manual1.2.pdf). Only the modification introduced in versions v10 to v12 are described below.

## NEW\_HYPERZ v12.0 to v12.2 UPDATES

---

The differences of the released v12 with respect to the standard package are the following:

1. The new parameter's file is : new\_hyperz.param . When running the code, a [ ].hyperz file is created to backup the current parameters.
2. Output file [ ].header\_zphot provides the header content for [ ].z\_phot file.
3. **Compilation update :**
  - The file *Makefile* contains the procedure for compilation. Just run :
    - make new\_hyper
    - make make\_catalog
    - make clean
  - The dimension of the hypercube can be modified by changing the dimension file dimension.dec as follows:

Present values:

PARAMETER (mxz=305,mxage=51,mxtyp=15,mxfl=15,mxred=18,

. mxlyf=3,mxwl=4000)

i.e.: up to mxz=305 redshift spets (usual ranges :  $z=0-6$ ,  $dz=0.02$ )

up to mxage=51 (optimum value for Bruzual & Charlot templates)  
 up to mxtyp=15 templates => modify if needed  
 up to mxfil=15 filters => modify if needed  
 up to mxred=18 reddening steps => modify if needed  
 up to mxlyf=3 lyman forest opacities (allowed values = 1 to 3)  
 up to mxwl=4000 points per template => modify if needed

4. **New templates** : Version v11 and later are able to read Maraston templates, in addition to the usual Bruzual & Charlot (BC), Starburst99 (S), and ascii templates (AS) distributed in the initial version. Maraston templates should be identified as "MA" in the templates's file, e.g.:

```
csp_e0.10_z02_salp.sed_agb      MA
csp_e0.25_z02_salp.sed_agb      MA ...
```

Versions v10 and later are able to read Starburst99 models: flag "S" (same syntax as above)

5. **Filter transmissions** : The new FILTERS\_FILE input file includes an additionnal (#6) column allowing the combination of filters with T(lambda) given in energy AND in photons within the same input catalog. The value of this column should be = 1 (if T(lambda) is in % of energy) or =2 (if T(lambda) is in % of photons). Default value =2 (in versions v10 and later).
6. **Absolute magnitudes** : Up to 10 output filters can be requested when computing absolute magnitudes for the best fit, instead of a single filter in the previous version. The first filter is still the "reference" for M\_ABS\_MIN and M\_ABS\_MAX. The syntax is as follows :

```
FILT_M_ABS  91,224,225,226,227,228  # filter for absolute magnitude
```

7. **Scaling modes for absolute magnitudes** : There are 2 scaling modes for absolute magnitudes:

```
MSCALE_FILT_M_ABS  1 # 1: Absolute magnitude scaled to the "reference" filter (default;
                    compatible with previous versions)
                    2 # Global scaling according to best-fit template, irrespective of
                    the "reference" filter
```

8. **Galactic de-reddening** : A new option is introduced allowing to ingest an E(B-V) value for each object in the input catalogue, in addition to the usual one. This new parameter is EBV\_unit should be set to a value >0 to indicate the existence of an extra column in the input catalog where this information is found. This option is useful for large catalogs covering a wide area on the sky, as for EUCLID data. The new\_hyperz.param file reads as follows :

```
EBV_MW          0.00897 # E(B-V) for galactic dereddening
EBV_unit         0  # >0, read galactic E(B-V) for each object in input catalog
                  # = 0: no E(B-V) column is provided
```

9. **Classification of extragalactic sources** is activated by the optional parameter REF\_TEMPLATES\_FILE . This parameter introduces a list of ASCII reference templates (default value, the CWW + a Kinney starburst). When this parameter is activated, in addition to the usual hyperz output, the \*.z\_phot file contains 1 + N(templates) additional columns with the following information:
  - 1- Best fit reference template (value ranging from 1 to N(templates))
  - 2- Reduced  $\chi^2$  for the best fit with each reference template at the  $z_{\text{best}}$  redshift.
 These are THE LATEST COLUMNS in the .z\_phot file if this option is activated. Example of use :

```
REF_TEMPLATES_FILE  reference_spectra.param # "Reference" ASCII templates
```

10. **Robustness of the fit** (photoz quality) : There is an additional column in the normal output \*.z\_phot file, between the absolute magnitudes and the Lyman opacity, with the integrated probability  $P_{\text{int}}$  between  $z_{\text{best}} \pm 0.1$ , which is an indicator of the goodness of the fit. The probability distribution  $P(z)$  is arbitrarily normalized to 100% between  $z_{\text{min}}$  and  $z_{\text{max}}$ .

11. **PDF** : An optional parameter PDZ\_FILE in the new\_hyperz.param file activates the output of a PDF. The format of this file is 1 line/object, with  $P(z)$  for  $z=z_{\text{min}}$  to  $z_{\text{max}}$ , with  $dz=Z_{\text{STEP}}$ . The PDF is normalized as in point 9 above.

12. **Stellar-Mass scaling** : There is an additional column with a physical scaling of the normalization "b" parameter translated into physical units. This provides a direct model of the stellar masses scaling WHEN MODEL MAKES SENSE (e.g. for the Bruzual & Charlot models) as follows :

$$\begin{aligned} F_{\text{lambda}}(\text{intrinsic}) &= b_{\text{scale}} * F_{\text{lambda}}(\text{model}) \quad (b_{\text{scale}}: \text{physical scaling}) \\ F_{\text{lambda}}(\text{intrinsic}) / [(1+z)^4 * \pi * d_{\text{lum}}^2] &= b * 2 \times 10^{(-17)} * F_{\text{lambda}}(\text{model}) \\ b_{\text{scale}} &= b * 2 \times 10^{(-17)} * [(1+z)^4 * \pi * d_{\text{lum}}^2] \end{aligned}$$

Ex: For Bruzual & Charlot models :

Bursts & e-folding models are given in solar luminosities/ solar\_Mass, with  $L_{\text{solar}} = 3.90 \times 10^{(33)} \text{ erg/sec}$   
 $\Rightarrow b_{\text{scale}} \sim \text{solar\_Masses} * 3.90 \times 10^{(33)}$  typically ( $b_{\text{scale}} \sim \text{up to } 10^{(43)}$ !). Given the typical values of this parameter,  $b_{\text{scale}}$  is given in  $\log(b_{\text{scale}})$  units.

13. **Normalization changes** : The flux output in the \*.obs\_sed file (if option selected is erg/s/cm<sup>2</sup>/Å) is in  $10^{-17}$  units instead of  $2 \times 10^{-17}$  in versions older than v10.

14. **Cluster mode** : The cluster mode is activated as in the previous versions by the Z\_CLUSTER parameter. In addition to the usual options in this mode, 2 additional optional parameters have been introduced as follows :

ZP1	0.10 # $z_{\text{min}}$ for integrated $P_z$
ZP2	0.80 # $z_{\text{max}}$ for integrated $P_z$

These parameters generate an additional output file \*.proba\_int containing the integrated  $P(z)$  between  $z \pm dz$ , between ZP1 and ZP2, 1 column per  $z$  bin.

In addition, when the Z\_CLUSTER option is activated, 2 additional columns are also given in the \*.z\_phot file containing the  $P_{\text{int}} \pm 0.05$  and  $P_{\text{int}} \pm 0.10$ , same normalization as in the point 9 above.

15. **Luminosity prior** : v12 allows the introduction of a luminosity prior when computing photometric redshifts. The parameters of the usual Schechter function can be specified as follows in the new\_hyperz.param file :

M_STAR	-21.0 # Schechter $M^*$ for luminosity prior on # reference $M_{\text{ABS}}$
ALPHA	-2.0 # Schechter alpha for luminosity prior